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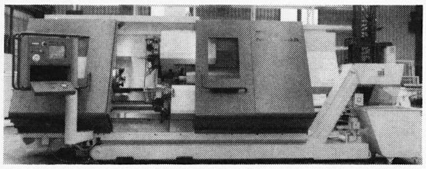
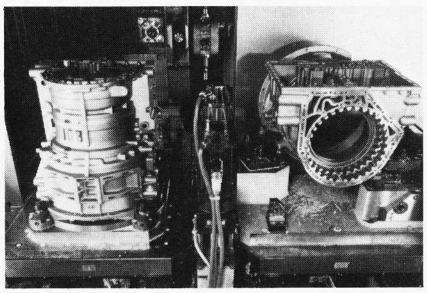
CNC Turning



This article describes a CNC Turning Machine with two or four controlled axes. It permits not only facing and turning but also the complete machining of workpieces by adding additional boring and milling units. This allows greater utilization.

Machining of Gear Boxes



An availability of high-tech modular units for machining and gauging, for workpiece and tool handling and control data processing is a requirement for the solution of difficult user orientated machining problems. Furthermore, a close co-operation between user and manufacturer in adapting all components to the machining task is required to provide a well functioning flexible manufacturing system. A flexible manufacturing system installed by the manufacturer of gear boxes for commercial vehicles and buses is used as an example to explain further details.

Upstream Quality Assurance

For the quick and individualized adaptation of series production to customer wishes which has become necessary and the simultaneous necessity of reducing the lot sizes in order to minimize the material in circulation, the quality assurance systems that have been perfected and used up to now have often proven too sluggish. A preventive quality assurance method will be presented here which has been successfully used in the all-wheel drive technology at Steyr-Daimler-Puch in Graz.

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Quality assurance seems to be so simple: sufficiently careful inspection and one has done everything to get a perfect product. This procedure has been used, perfected and automated all over the world – just think of the last generation of inspection robots – and still we are dissatisfied with the results. Yes, we are helpless before problems which we did not anticipate in our inspection plans. Even when we search through our files which are burgeoning with statistical analyses, we very often find no data which could make a quick solution of an unexpected problem possible.

Where is the false reasoning in our quality assurance systems? Our mistake seems to be that we are accustomed to extrapolate the past – quality assurance history up to now – and to base our inspection strategies on these "experiences". In itself, this is a logical procedure.

However, I believe that we should overcome past quality assurance of our technologies and products instead of multiplying it further. It seems much more important that we find methods to locate and deactivate trouble potentials even before such defects crop up. These techniques will be called "Upstream Quality Assurance" in the following.

This abstract definition harbors the danger that the guiding principle, i.e. to "deactivate trouble potentials before defects crop up", becomes lip service without actual effect, which is, unfortunately, what happened to the well-known principle of "quality must be achieved through the production process and not through inspection".

Therefore, I would like to explain why the quality assurance methods which have been used up to now in the automotive industry must be complemented by the considerations mentioned. Finally, using some examples from our all-wheel technology center in Graz, I will explain how steps can be taken toward an effective "upstream quality assurance" (i.e. preventive quality assurance).

1 Initial situation

Right now, there is a trend in the automotive industry to detach Production from the error possibility of the worker as far as possible by installing large-scale inspection systems. These have to be as automated as possible in order to eliminate the human element as far as subjective judgement and questions of reliability are concerned.

The initial euphoria that greeted statistical quality inspection as a direct instrument of quality assurance has retreated before the realization that processes must be streamlined along economic lines under the enormous pressure of world-wide competition. Considering the many features which influence the safety of a vehicle, production must either be assured by suitable precautions or must be followed by 100% inspection. Therefore automated inspection during or after production can be used very successfully in a large, stationary series production.

But the world-wide economic situation forced everyone to reconsider their approaches. It is becoming ever more indispensable to offer each customer an individually configured vehicle and that means innumerable elements and modules and even more possibilities of combining them.

At the same time, buffer and stock reduction to minimize tied up capital results in ever decreasing single lots. For quality assurance, this means a highly increased number of influence and feature parameters. Here, man as planner is being overtaxed, for he must eliminate all error potentials analogously to the past. Here at the very latest, we are forced to tackle the problem of other ways of quality assurance.

Even the opinion that a fully automated production and assembly works error-free turns out the be an illusion. It is an irony of our belief in technology to see how in most modern, automated assemblies people are climbing in and around the machines to correct defects that occur when parts are joined or screwed together by automated equipment. Therefore, full automation is not a solution to the problem of quality assurance, but a further challenge.

The same tendencies come up in quality assurance of incoming material. The admissible defect percentages (AQL – Acceptable Quality Level) are so small that no one can afford the statistically necessary operational characteristics in incoming inspection. This is especially true because deliveries are scheduled to reduce the floating capital and with the "just in time" and "Canban" methods, this keeps the delivery lots relatively small but ever more frequent, so that only full inspection can make quality assurance in the traditional sense possible.

The situation is aggravated by increasing PPM demands, i.e. for the further production deviations in the volume of not more than 1 to 1 million can be tolerated. These demands cannot be efficiently and economically assured by incoming inspection. Here, too, the only possibility is to assure quality upstream at the supplier's premises.

The first step in the direction of upstream quality assurance of purchased material is very well described in the VDA[1])-bouclet "Quality assurance of supplied material in the

1 German Automotive Industry Association.

Fig. 1. Measuring room for 4-wheel transmission & suspension parts fitted with coordinate measuring machines from Carl Zeiss, Oberkochen, W. Germany

Fig. 2. Steyr-Puch Pinzgauer adjustment verification

Fig. 3. Cross-country vehicle G in operations planning shop

automotive industrie/supplier and initial sample evaluation". The use of these procedures is increasing internationally. However, it is extraordinarily difficult to find suitable ways for one's own production.

2 Shifting quality responsibility to the site of quality process

In our all-wheel center in Graz, we have experimented with making our workers fully responsible for quality at the site of production. The objectives and judgement criteria of the quality features are agreed upon with the workers and are binding and thus, they have the pre-requisites to attain them. Within the framework agreed upon, they are considered fully competent to judge the quality objectives which have been targeted.

When the workers know that they are not only collectively, but personally responsible and that the personal quality achievement can be connected to a specific person even at a later date, one can achieve such a high grade of identification with the task that unplanned procedure deviations are recognized which were not in a conventional post-production inspection plan and therefore, would not have been automatically found.

But it is even more important that this kind of quality motivation insures that the workers observe peripheral production conditions in their own interest and all changes are reported before defects crop up in the production process. That is exactly the effect that we wanted.

It is interesting to note that after such an adjustment defect correction costs decrease noticeably. Even the subsequent rework which can never be completely avoided decreases, since it is initiated by Production itself and not by a separate downstream-inspection. The occupational pride of the workers is so to speak on the line when one has to hand over parts for subsequent work to another department.

3 Audits to check reliability of the individual responsibility systems

The procedure for individual responsibility is very effective quality assurance-wise, but it is not easy to handle by the quality assurance department, since the direct intervention after each production stage is no longer possible, but at the same time, assessment must be continuous to observe how well the system is functioning.

If one dares to take the step toward individual responsibility for quality of Production, one needs sensitive audit systems in order to insure the effectiveness of the system. But care must be taken. The dynamics of quality control loops which are controlled by audit systems are different from processes which are controlled by warning boundaries or the customary safety net controls.

In individually responsible production there must never be an impression that the audit system can directly assure quality of parts, aggregates, vehicles or single lots. This must remain within the sphere of individual responsibility.

Product audit for vehicles, aggregates and parts sets, *procedure audit* for technology and procedure steps and *system audit* for the whole organizational and handling processes must render account on whether the individual systems are working reliably enough on one hand and must locate points where improvements are necessary and can be implemented on the other hand.

It is a difficult new task for the quality technicians who are used to statistically following hundreds of procedure parameters and then taking inspection planning from there to effectively influence and improve the pre-requisites and peripheral conditions of processes by means of information gathered via the audit system.

It has proven effective to take one point per procedural step from all new quality input each month on priority and work on it. This must, of course, be a point which exercises an essential influence on the process and must be a point which really can be modified. For this point of main effort, the quality assurance department – together with all the specialized departments – must carry out a study of the causes and effects, as well as parameter studies in the form of a problem inquiry. Then improvement measures must be taken together with all the departments concerned. This way, the process periphery will be systematically improved as much as the capacities and demands allow so that the capability and reliability of individually responsible production keeps getting higher and higher.

The effects are comparable to the efforts to continually improve the cp (capability) factors, i. e. the relationship between the tolerance field and the process range. These efforts are a matter of course in Japan, but have not yet been fully understood in Europe.

4 Upstream quality assurance at the start of new series production

One can be most successful at the beginning of new series, when all parameters which influence quality can be registered, considered and coordinated.

Today's market makes frequent model modification necessary – and that upon short notice. The large range of combinations cannot be completely tested in the pilot series of the basic model. Here a procedure is needed that makes it possible to coordinate design features, production possibilities, actual status of parts, processes and functional demands during the introduction of modifications and model variants quickly and in a quality-wise satisfactory manner so that a reliable production can start up immediately.

The following way has proven successful: Measurement of all tools, installations, parts and assemblies in the precision measurement shop (illustration 1) and/or by a chassis measurement machine (illustration 2) assembly studies in an operations planning shop (illustration 3).

On the basis of process capability investigations in the past, parameter studies are carried out and constructional data, production possibilities and functional demands are coordinated by all the specialized departments involved. This must be done before and during the start of new series assemblies until reliable production has been achieved and the quality can actually be guaranteed by production through individual responsibility. This way we can satisfy our very demanding customers like Fiat, Lancia, VW or Daimler-Benz. Of course, this system also fulfills the NATO qualification AQAP 1.

All illustrations by courtesy of Steyr Daimler Puch AG, Graz, Austria. The author is with this company in the quality management departement.